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Develop a risk stratification model and clinical analysis to predict the impact of primary percutaneous coronary intervention on complete AV block in acute inferior STEMI patients

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Abstract---Background: Acute inferior ST-elevation myocardial infarction (STEMI) is medical emergency entailing immediate intervention to restore blood flow and mitigate myocardial damage. Primary percutaneous coronary intervention (PCI) has replaced thrombolytic therapy as preferred treatment strategy for having superior outcomes. Objectives: To develop a risk stratification model incorporating the identified predictors to estimate the individual risk

of complete AV block in patients undergoing primary PCI for acute inferior STEMI. Methods: This study enrolled 139 patients diagnosed with acute inferior STEMI who underwent primary PCI at the hospital. They were divided into two groups, *i.e.* pre-operative and post-operative carrying 54 and 85 patients, respectively. On admission, demographic, clinical data and peak values of cardiac biomarkers were obtained and the complications associated with PCI were elaborated. Results: Mean age of patients was 59.81±8.19 years, and comprised significantly more male (97) than female (42) patients ($p<0.05$). Proportion of patients with a history of complete AV block was 10.79%. Comorbidities included diabetes mellitus (33.09%), hypertension (49.64%), and dyslipidemia (64.74%). Coronary angiography findings for predicting AV block in patients with STEMI were categorized by location of culprit lesion in coronary vessels. Complexity levels of culprit coronary lesions were found in 9.35, 48.20 and 42.44% of patients having Type A, B and C level lesions. Clinical outcomes, such as creatinine phosphokinase levels, creatinine phosphokinase-MB levels, ejection fraction, maximal TIMI flow score, and patient satisfaction were comparatively high in patients treated with PCI, while incidence of MACE was substantially lower in PCI-treated patients ($p<0.05$). Practical Implications: It would contribute to the refinement of clinical guidelines and protocols for managing patients undergoing primary PCI with acute inferior STEMI. Conclusion: PCI had significant efficacy in relieving complete AV blockage and patient satisfaction and substantially declined creatinine phosphokinase levels and enhanced TIMI blood flow, with minimal MACE proportion.

Keywords---atrioventricular block, cardiology, hemodynamic stability, procedural success, risk assessment, STEMI.

Introduction

Acute STEMI is a cardiovascular emergency requiring urgent medical attention ¹. Acute inferior STEMI is a subtype of STEMI that is characterized by the blockage or occlusion of main arteries supplying the lower portion of the heart, specifically the right coronary artery (RCA) and its branches ². This obstruction results in inadequate blood supply, which damages heart muscle and causes necrosis ³⁻⁴. Atrioventricular (AV) block is cardiac disorder whereby signal from the heart's upper chambers (atria) is either delayed or prevented from reaching the lower chambers (ventricles). This disruption can result in an irregular and frequently sluggish pulse, which may cause a decrease in blood pressure and syncope. There are three degrees of AV block severity: first-, second- (Mobitz types I and II), and third-degree (complete heart block). Each stage has unique characteristics and may necessitate varying levels of treatment, including the implantation of a pacemaker in more severe cases ⁵⁻⁶.

Age, cardiovascular disease, certain medications, and electrolyte imbalances are risk factors for AV block. Depending on the severity of AV block, symptoms range

from fatigue, vertigo, and shortness of breath to syncope or no symptoms⁷. Rapid and precise diagnosis of acute inferior STEMI is essential for prompt treatment. Electrocardiogram (ECG), which detects ST-segment elevation in lower leads (II, III, aVF), is a valuable diagnostic instrument for assessing myocardial damage. In addition, cardiac biomarkers such as troponin levels and imaging techniques such as echocardiography can be utilized to affirm the diagnosis and determine the extent of the damage⁸⁻⁹.

Primary percutaneous coronary intervention (PCI), also known as angioplasty, is essential for the treatment of inferior acute STEMI. By inserting a catheter into a peripheral artery and guiding it to the afflicted coronary artery, this non-surgical procedure restores blood flow. By inflating a balloon at the catheter's tip, blood flow is restored by compressing the obstructive plaque against the artery wall. Typically, a stent is inserted at the site of the obstruction to prevent further constriction¹⁰⁻¹¹.

PCI is favored over thrombolytic therapy due to its superior outcomes, which include lower mortality rates, fewer recurrent heart attacks, and decreased incidence of stroke¹²⁻¹³. However, primary PCI entails its risks, including bleeding, blood vessel damage, arrhythmias, and, in extremely rare instances, heart attack or stroke. Therefore, a thorough risk-benefit analysis is required for every patient. PCI continues to play key role in treating STEMI, and efforts to improve its accessibility and safety are crucial in the battle against cardiovascular disease¹⁴.

Patients with inferior AMI bear better prognosis over those with anterior AMI, but their risk profiles vary. It includes cardiogenic shock, advanced age, concurrent ST-segment depression in left precordial leads, complete atrioventricular block, and right ventricular infarction. Angioplasty (PCI) is the primary treatment modality for acute inferior STEMI, which is treated with a multidisciplinary approach to restore blood flow, alleviate symptoms, and prevent further complications^{4, 15, 16}.

Our primary objective was to develop a robust, evidence-based model that identifies and analyzes key clinical and angiographic parameters associated with the occurrence of complete AV block in inferior STEMI. In addition, we sought to ascertain the predictive value of these factors and incorporate them into a future risk stratification model. The impact of complete AV block on clinical prognosis of patients undergoing primary PCI was determined by evaluating mortality rates, MI recurrence rates, and hospital readmission ratios.

Material and Methods

This cross-sectional study was conducted at Peshawar Institute of Cardiology during the years 2021-23, investigating 139 patients diagnosed with acute inferior STEMI who underwent primary PCI at the hospital. The sample size was calculated using WHO calculator keeping 10% population proportion at 95% confidence interval and 5% marginal error. Participants were divided into two groups, *i.e.* pre-operative (STEMI patients recovered without PCI, who were

maintained on standard thrombolytic therapy) and post-operative (STEMI patients recovered after PCI) (Figure 1).

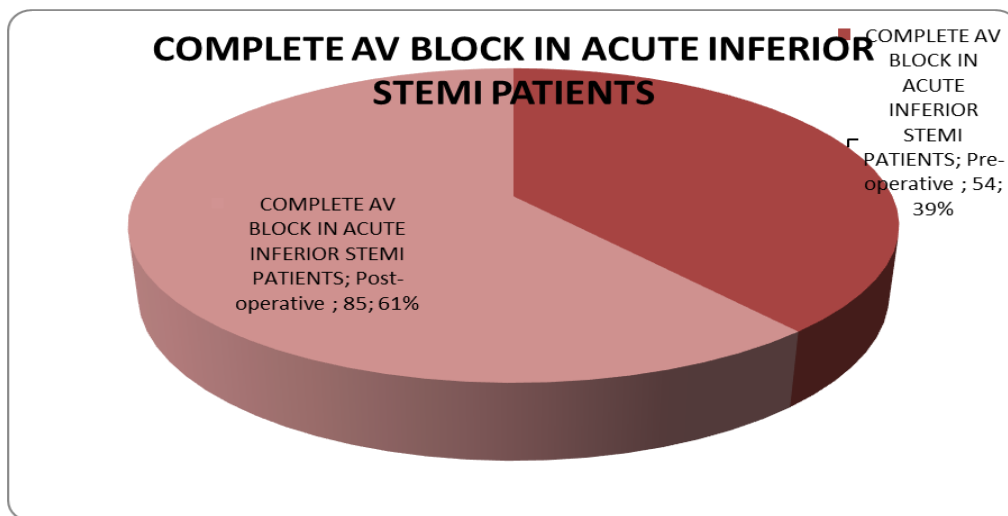


Figure 1: Patients' group allocation

This single-center study included patients with having confirmed inferior STEMI, admitted within 24 hours of symptoms onset. The diagnosis was based on a history of chest pain, enzyme measurements, and electrocardiogram (ECG) findings, per WHO criteria. AMI cases with serially observed increases in CK and CK-MB activities were considered acute events. ST-segment elevation of at least 0.1 mV in at least two of leads II, III, and aVF was used to define inferior AMI. ST-segment elevation of at least 0.1 mV in lead V4R indicated involvement of the right ventricle.

All enrolled patients underwent coronary angiography within 30 minutes and PCI immediately, unless adequate hemodynamic stabilization permitted transport to the catheterization laboratory. All patients were administered a parenteral loading dose of 500 mg acetylsalicylic acid (aspirin) and 5000 IU of unfractionated heparin upon admission¹⁷. Study incorporated the patients diagnosed with acute inferior STEMI, with atrioventricular blockage and treated with primary PCI during study period. Patients must be at least 18 years old with onset of symptoms within 24 hours, able to give informed consent and planned for PCI as reperfusion therapy.

Exclusionary standards contained preexisting complete AV block, patients with pacemakers, contraindications to PCI, lack of comprehensive data, and patients who refused to participate in the study. Moreover, patients with contraindications to PCI, including active bleeding or recent significant surgery, with a known allergy or intolerance to PCI medications and individuals with a history of complete atrioventricular (AV) block or pacemaker implantation were excluded too. Individuals who were pregnant or nursing were not permitted to participate. The inability to comply with study procedures or attend follow-up appointments resulted in exclusion from the study. Those who currently joined another clinical

trial involving investigational medications and medical devices that might confound the results of the present study were also excluded.

On admission, demographic and clinical data were obtained from all patients and recorded. Based on the use of medications designed to treat hypertension, diabetes, and congestive heart failure, presence of such ailments was determined. Multivessel disease was defined as the presence of at least 50% stenosis in two or more main epicardial coronary arteries. As part of the analysis, complex lesions, known as Type C-lesions, were identified. Recurrent AMI was defined as the reappearance of chest discomfort accompanied by an increase in cardiac biomarkers greater than five days after PCI. Peak values of cardiac biomarkers were obtained, however, various biomarkers and assays were used during the study period. Left ventricular ejection fraction (LVEF) was also recorded. Primary PCI was performed in accordance with current interventional guidelines. All patients' vital status and cause of death were noted respectively ¹⁸.

Post-PCI development of complete AV block was the principal outcome. In-hospital mortality, recurrent MI, and hospital readmission rates were secondary outcomes. On the basis of patient characteristics, clinical presentation, and angiographic and procedural factors that substantially correlated with the occurrence of complete AV block following PCI, a risk stratification model was developed. The progression of AVB was categorized as third-degree to second/first-degree/normal, Mobitz type II to type I/first-degree/normal, or Mobitz type I to first-degree/normal. No flow, low flow, coronary perforation, stent thrombosis, and cardiac mortality were identified as PCI-related complications ¹⁹. Data were summarized with descriptive statistics. For categorical and continuous variables, Chi-square and one-way ANOVA test was employed using SPSS 25.0. This investigation adhered to outlined principles in Helsinki Declaration. The respective hospital's Institutional Review Board was also consulted, and participating patients provided informed consent.

Results

Our study included a total of 139 patients with acute inferior STEMI and complete AV block. They were divided into two groups, with 85 patients receiving primary PPCI and 54 recovering without PCI while receiving standard thrombolytic therapy. Risk stratification model for predicting AV block in patients with inferior STEMI indicated that patients had mean age of 59.81±8.19 years. But the study comprised significantly more male (97) than female (42) patients ($p < 0.05$). Portion of patients with the history of complete AV block was 10.79%. Pre-existing heart anomalies were reported by 12.94% of patients. Comorbidities included diabetes mellitus (33.09%), hypertension (49.64%), and dyslipidemia (64.74%). Diabetes mellitus was statistically significant (p -value = 0.000678) among these risk factors. Smoking was statistically significant risk factor (p -value = 0.00055), with 31.65% of patients being smokers. 20.14 % of patients had genetic predisposition ($p < 0.05$), while 26.61 percent of patients were obese ($p < 0.05$). Average troponin concentration was 0.47±0.07 ng/ml ($p < 0.05$). Prior AMI was experienced by 9.35% of patients ($p < 0.05$) (Table 1).

Coronary angiography findings for predicting AV block in patients with STEMI were categorized by location of culprit lesion in the coronary vessels of both pre- and post-operatively groups. 39 patients had the culprit lesion in RCA prior to surgery, and patients with the culprit lesion in the left main coronary artery (LMCA) increased from 1 in pre-operatively and in 2 post-operatively group. Lesions in LAD artery were 7 and 11, while the causative lesions in circumflex artery were 3 and 9 in pre-operative and post-operative groups, respectively. Posterior descending artery (PDA) had lesions in 4 and 6 patients. Pre- and post-operatively, location of causative lesion in coronary vessels (RCA, LMCA, LAD artery, circumflex artery, or PDA) were not significant predictors of AV block in patients with acute inferior STEMI (Table 2).

In pre-operative group 11.11 percent of patients (6 out of 54) had complete AV block ($p < 0.05$), compared to 20.0% in PCI group (17 out of 85). The rate of hospital readmission was 31.48% in pre-operative and 15.22% in PCI group. Incidence of cardiac complications was nearly identical in non-PCI and PCI groups *i.e.* 9.25% vs. 8.23%. Average duration of hospitalization was 3.13 and 4.01 days in both groups, respectively. The rate of other adverse events were 12.96% preoperatively and 7.05% postoperatively. Rate of patient satisfaction was considerably from 46.29 percent prior to surgery to 69.41 percent after surgery (p -value = 0.00001). This indicated that patients were substantially happier after PCI (Table 3).

Using American Heart Association lesion classification system, the complexity of a culprit lesion in coronary artery disease is categorized according to their morphological complexity. Lesions of type A are the least complex, discrete, concentric, readily accessible, and limited in area. They have a uniform contour and are not situated near a significant branching point. Lesions of type B are moderately complex, of moderate length, eccentricity, area, or irregular contour. They may be situated at a major branch point or entail moderate proximal segment tortuosity. Lesions of type C are the most complex, exceptionally long, involve a large area, have an irregular contour, or involve a proximal segment with excessive tortuosity. Additionally, they may be situated at a bifurcation with significant side branch involvement, be completely occluded, or contain thrombus or calcification. This classification is frequently used to estimate the technical difficulty and complication risk of PCI. In our findings, complexity level of culprit coronary lesion was shown in Figure 2 whereby 9.35, 48.20 and 42.44% patients had Type A, B and C level lesions.

Procedural data of clinical outcomes for STEMI patients were recorded and it was found that both PCI-treated and without-PCI values were comparable. The data illustrated the variety of clinical outcomes, such as creatinine phosphokinase levels, creatinine phosphokinase-MB levels, ejection fraction, maximal TIMI flow score, and patient satisfaction. Average level of creatinine phosphokinase, an enzyme frequently elevated after a heart attack, decreased from 2148 U/L pre-operatively to 1704 U/L post-operatively. This decrease was statistically significant (p -value = 0.00001), indicating that PCI assisted in reducing this enzyme's concentration. The ejection fraction, a measure of cardiac function, increased from a pre-operative median of 53.17 percent to a post-operative median of 66.45 percent. This increase, however, was not statistically significant

(p-value = 0.1765), indicating that the observed difference could be due to random chance. The maximal TIMI (Thrombolysis In Myocardial Infarction) flow score, which measures blood flow within the coronary arteries, was 3 in 59.25% of pre-operative patients and in 78.82% of post-operative patients. The increase was statistically significant (p-value = 0.0134), indicating that PCI enhanced blood flow in these patients. Lastly, patient satisfaction increased from 46.29 percent without PCI to 69.41 percent with PCI (Table 4).

Incidence of major adverse cardiac events (MACE) with and without PCI in patients with STEMI was comparatively studied and included the conditions of MI recurrence, revascularization, stroke, and mortality. The rate of recurrent MI, which implies multiple episodes of MI, decreased from 14.81 percent without PCI to 12.94 percent in PCI group, suggesting that PCI had contributed to reduction in risk of experiencing a second heart attack. The rate of revascularization, a procedure that restores blood flow to the heart, decreased from 12.96% without PCI to 7.05% in PCI group. This decrease suggested that PCI had positive impact on reducing the need for additional revascularization procedures. Incidence of stroke, a condition that occurs when blood supply to a portion in brain is interrupted, decreased from 5.55 percent to 3.52 percent in both groups indicating that PCI procedure reduced the risk of stroke. The mortality rate among these patients decreased from 11.11 percent without PCI to 7.05 percent in PCI group presenting that PCI contributed to decrease in mortality among patients with STEMI (Figure 3).

Table 1: Risk stratification model for predicting AV block in patients for acute inferior STEMI

S. No	Risk factors	Hazard ratio	p-value
1	Age (Mean+SD) years	59.81+8.19	0.0782
2	Gender (n=male/female)	97/42	0.00018*
3	History of AV block n(%)	15 (10.79)	0.1903
4	Pre-existing heart anomalies n(%)	18 (12.94)	0.4066
5	Comorbidities n(%) Diabetes mellitus Hypertension Dyslipidemia	46 (33.09) 69 (49.64) 90 (64.74)	0.000678*
6	Smoking n(%)	44 (31.65)	0.00055*
7	Genetic predisposition n(%)	28 (20.14)	0.00001*
8	Obesity n(%)	37 (26.61)	0.00001*
9	Troponin levels (Mean+SD) ng/ml	0.47+0.076	0.00001*
10	Prior AMI n(%)	13 (9.35)	0.00001*

*indicated that the value is statistically significant (p<0.05)

Table 2: Coronary angiography findings for predicting AV block in patients for acute inferior STEMI

S. No	Culprit lesion in coronary vessels	Pre-operative (n= 54)	Post-operative (n=85)	x2	p-value
1	Right coronary artery	39	57	0.019	0.8902

2	Left main coronary artery	01	2	0.164	0.6855
3	LAD artery	07	11	0.064	0.7997
4	Circumflex artery	03	09	0.4085	0.5227
5	Posterior descending artery	04	06	0.0695	0.7920

Table 3: Comparison of clinical outcomes of patients with complete AV block following acute inferior STEMI treated with or without PCI

Study Variables	Pre-operative n= 54	Post-operative n= 85	p-value
Complete AV Block n(%)	06 (11.11)	17 (20.0)	0.0011*
Hospital Readmission	17 (31.48)	13 (15.29)	0.1950
Cardiac Complications	05 (9.25)	07 (8.23)	0.1411
Length of Hospital Stay (Mean+SD) days	3.13+1.41	4.01+1.66	0.2981
Other Adverse Events	07 (12.96)	06 (7.05)	0.5447
Patient Satisfaction	25 (46.29)	59 (69.41)	0.00001*

*indicated that the value is statistically significant (p<0.05)

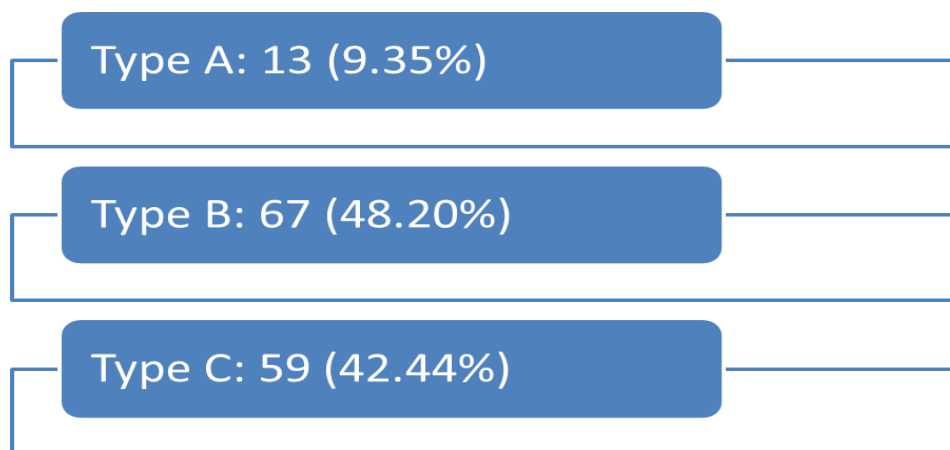


Figure 2: Complexity level of culprit coronary lesion

Table 4: Procedural data of clinical outcomes of STEMI patients

S. No	Clinical outcomes	Pre-operative (n= 54)	Post-operative (n=85)	x2	p-value
1	Creatinine phosphokinase U/L	2148+234	1704+179	0.3436	0.00001*
2	Creatinine phosphokinase-MB U/L	189+34	151+17	2.7641	0.0963
3	Ejection fraction (%)	53.17 (40-60)	66.45 (55-70)	3.1980	0.1765
4	Maximum TIMI flow	32 (59.25%)	67 (78.82)	6.1044	0.0134*

	score=3				
5	Symptoms relief and patient satisfaction n(%)	25 (46.29)	59 (69.41)	1.5136	0.2185

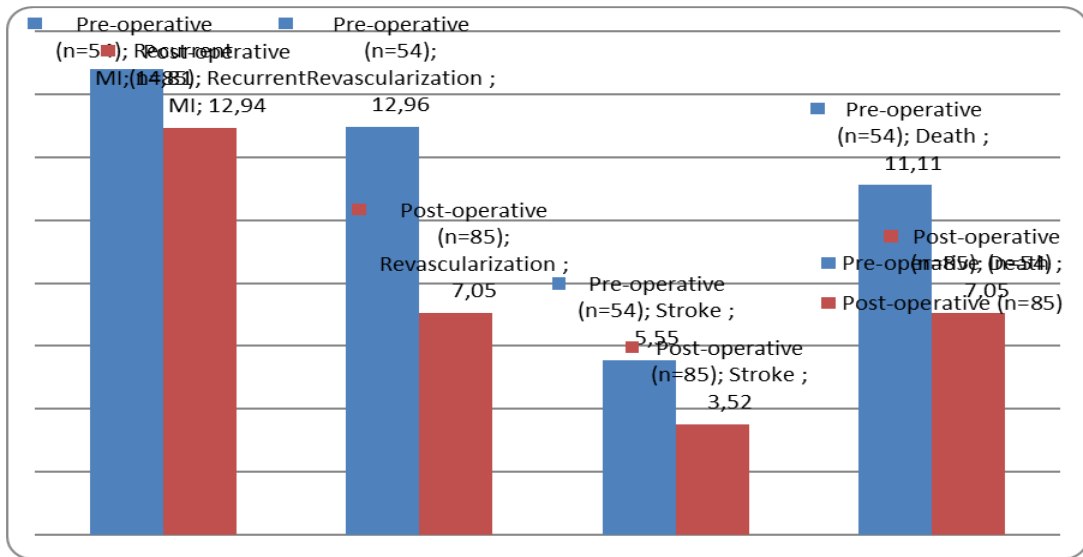


Figure 3: MACE of study groups 30 days post AMI

Discussion

There were substantially more male patients (97) than female patients (42). A total of 10.79% of patients had a history of complete AV block. Included among the comorbidities were diabetes mellitus (33.09%), hypertension (49.64%), and dyslipidemia (64.74%). Location of culprit lesion in coronary vessels was used to classify the coronary angiography findings for predicting AV block in patients with STEMI. The complexity level of the culprit coronary lesion, with 9.35%, 48.20%, and 42.44% of patients having Type A, B, and C lesions, respectively. Clinical outcomes, including creatinine phosphokinase levels, creatinine phosphokinase-MB levels, ejection fraction, maximal TIMI flow score, and patient satisfaction, were significantly higher in PCI-treated patients, whereas the incidence of MACE was significantly lower. This research was able to develop a risk stratification model for predicting the effect of primary PCI on complete AV block in patients with acute inferior STEMI. According to the study, PCI was associated with significant effectiveness in alleviating complete AV blockage and with patient satisfaction. In addition to significantly decreasing creatinine phosphokinase levels and improving blood flow, the procedure reduced the incidence of severe adverse cardiac events.

Another correlated study enrolled 151 patients having inferior STEMI. Primary PPCI was performed on all of these patients and clinical outcomes of them were compared who developed complete atrioventricular block (CAVB) to those who did not. Half of all patients had diabetes or hypertension, which was a characteristic shared by all patients at baseline. 21 (13.9%) of the 151 participants developed

CAVB. Notably, after PPCI, 2/3rd of those who developed heart block experienced reversal. After two weeks, there was no significant difference between the groups in terms of hospital mortality. Findings suggested that PPCI improved the prognosis of patients with STEMI complicated by CAVB and was recommended as the preferred reperfusion therapy for patients with CAVB and STEMI ²⁰. Following PCI procedure, a sinus rhythm was restored in 14 patients (66.6%), but not in seven (33.34%) patients. The incidence of CAVB was marginally higher than the 11.3% incidence reported by Kim et al. Remarkably, in-hospital mortality rate was only 3.3% ²¹.

Following PCI, echocardiography revealed a significant improvement in systolic and diastolic functions of right ventricle (RV), particularly in proximal and middle right coronary artery (RCA). RCA revascularization significantly improved patients with RV dysfunction, indicating that it is a viable treatment option for patients with RV dysfunction ²². Primary PCI can effectively mitigate the complications of CAVB in patients with acute inferior STEMI, with an acceptable rate of significant MACE. Therefore, it was proposed that primary PCI should be regarded as the preferred reperfusion therapy for patients with acute inferior MI complicated by CAVB ¹⁶. According to a separate study, there were no PCI-related complications or deaths, and all AVB patients recovered fully prior to discharge. Early PCI was regarded safe and should be promoted as primary treatment for patients with inferior STEMI presenting late with AVB. Under these conditions, successful reperfusion of the artery associated with the infarct is advantageous for promoting AVB recovery ¹⁹. According to research conducted by Chinese scientists, patients who undergo PCI one week or more after the onset of symptoms have higher survival rates and fewer adverse events ²³.

Conclusion

This study enabled to construct a risk stratification model to predict effect of primary PCI on complete AV block in patients with acute inferior STEMI. Gender, comorbidities, smoking, genetic predisposition, obesity, troponin levels, and prior myocardial infarction were identified as key risk factors. PCI was associated with significant efficacy in relieving complete AV blockage and patient satisfaction. In addition to substantially reducing creatinine phosphokinase levels and enhancing blood flow, the procedure reduced the incidence of major adverse cardiac events. However, these predictions are not conclusive; additional research is required for validation.

Conflict of interest

None.

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